Field-tuned Collapse of an Orbitally Ordered and Spin-polarized State: Colossal Magnetoresistance in Bilayered Ruthenate

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$Ca_3Ru_2O_7$ with a Mott-like transition at 48 K features different in-plane anisotropies of magnetization and magnetoresistance. Applying magnetic field along the magnetic easy-axis (*a*-axis) precipitates a spin-polarized state via a first-order metamagnetic transition, but does not lead to a full suppression of the Mott state, whereas applying magnetic field along the magnetic hard axis (*b*-axis) does, causing a resistivity reduction of three orders of magnitude. The novelty of the bilayered $Ca_3Ru_2O_7$ is that ***the colossal magnetoresistivity is a result of the collapse of the orbitally ordered state that is realized by demolishing the spin-polarized state.*** This new phenomenon is striking in that the spin-polarization, which is a fundamental driving force for all other magnetoresistive systems, is detrimental to the colossal magnetoresistence in this 4d-based electron system!

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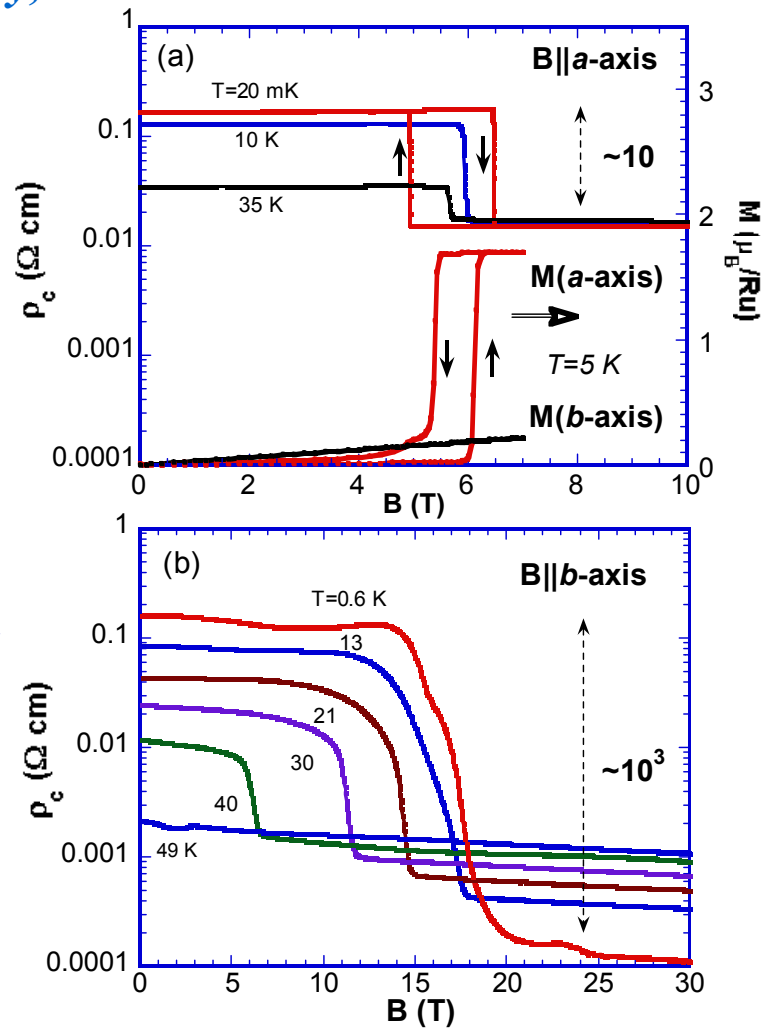

Field dependence of ρ_c for B||*a*-axis (a) and B||*b*-axis (b) for a few representative temperatures from 0.6 K to 49 K. M for the *a*- and the *b*-axis is shown in Fig. a (right scale)

Education

Four Ph.D. graduate students (from left to right) *Xiunu Lin, Shalinee Chikara, Esmat Elhami and Vino Durairaj* contributed to this work. Two of them have been supported by this grant, and all of them were supported during the summer, 2003.

The ruthenate crystal shown is one of many crystals grown by them using an optical floating zone furnace. It is in general a challenge to synthesize large single crystals. The high quality of their crystals suggests that they are ready to meet the challenge. This is encouraging particularly when there is a lack of scientists who specialize in both synthesizing new materials and growing large single crystals in US universities.